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Policy responses to GEC impacts on food availability and affordability in the Caribbean community

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ABSTRACT

This paper examines the range of global environmental change (GEC) issues that pose potential threats to the Caribbean region, with adverse consequences for food availability and affordability. Although GEC effects are beginning to manifest themselves globally, the region is yet to initiate action with regards to policy options and adaptation responses. This lack of response to date may be attributed to political leaders' pre-occupation with the current challenges confronting the region-economic decline, increasing debt, loss of livelihoods, increasing incidence of poverty and food insecurity. GEC would only serve to further exacerbate an already dire situation.

The paper firstly presents a description of the economies and agricultural systems of the Caribbean Community (CARICOM). It then examines the multiple stressors to the food systems, including recent GEC events and impacts, changes in food availability and changes in food affordability. Some livelihoods and some population subgroups, which are particularly vulnerable to these GECs, are then highlighted. The discussion concludes by exploring potential policy options and adaptation strategies for the region to counteract added GEC stress, in light of some similar global experiences.

1. Introduction

The Food and Agricultural Organization (FAO) of the United Nations introduced a refined definition of food security as '... a situation that exists when all people, at all times, have physical, economic and social access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO, 2002). Food availability and affordability are important components of food systems which underpin food security (GECAFS, 2005; Ericksen, 2008a). Food availability is dependent on food production, distribution and trade. Food affordability is linked with food pricing and consumers' purchasing power (Ericksen, 2008a). These factors are influenced by social, political, economic and environmental landscapes. Some claim that socio-economic and political issues have greater impact on food security, particularly in the short term, than environmental issues. However, environmental phenomena place an indisputable stress on food security outcomes, and are best understood and addressed when examined in conjunction

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Table 1 – CARICOM countries' selected economic and agricultural indicators, 2003.

Countries	Economy output related to GDP				Agricultural sector indicators	
	Total (constant 2000 US$) ('000)	Agriculture (%)	Industry (%)	Services (%)	Agricultural land ('000 ha)	Irrigated land (% of cropland)
Antigua/Barbuda	735108.864	3.77	21.08	75.15	14	N/A[a]
The Bahamas[b]	4938247.680	N/A	N/A	N/A	14	8
Barbados	N/A	4.47	16.12	79.41	19	29
Belize	1002899.968	16.65	17.49	65.86	152	3
Dominica	255990.720	18.28	23.07	58.65	23	N/A
Grenada	425590.496	9.77	24.14	66.09	13	NA
Guyana	728679.744	31.44	27.19	24.26	1740	29
Haiti	3711993.088	27.92	16.97	55.11	1590	8
Jamaica	8491644.928	5.49	31.66	62.84	513	9
St Kitts/Nevis	341550.560	3.03	28.09	68.99	10	N/A
St Lucia	682979.776	5.27	18.11	76.62	20	17
St Vincent/Grenadines	344594.816	8.76	24.48	66.77	16	7
Suriname	1012462.656	10.67	21.36	67.96	89	75
Trinidad/Tobago	10401797.120	1.1	51.53	47.37	133	3

Source: Compiled from World Development Indicators Online, World Bank (2007).
[a] Data not available.
[b] Data for the year 2002.

with the socio-economic and political drivers (Ericksen, 2008b).

Global environmental change (GEC) embodies change in the physical and biogeochemical environment caused by natural occurrences or societal actions. It involves changes in major earth systems and functions, such as climate change, and widespread local environmental changes, such as land degradation (Ingram and Brklacich, 2002). GEC also include sea level rise, changes in climate means and variability and climate extremes like hurricanes, floods, droughts and temperature extremes. Societal activities such as deforestation, fossil fuel consumption, agricultural intensification, fresh water extraction, fisheries over-exploitation and waste production also influence GEC (GECAFS, 2006, 2007).

Global environmental changes are evident throughout the Caribbean Community (CARICOM).[1] They threaten the status of food security in this region, exacerbating recent global economic threats, *inter alia* highly volatile food and oil prices, trade liberalization and receding economies. Whereas CARICOM may be powerless to reduce its exposure to GEC and other global threats, it is in a position to reduce GEC impacts on its food security. This would necessitate closer examination of its environmental, agricultural and, trade policies.

This paper first gives a history and the current status of CARICOM agriculture and its role in the economy. Secondly, it explores food availability and affordability within CARICOM food security, with examples of groups that are, or are potentially, food insecure. Next, it reviews environmental impacts on food production systems. Finally it explores ways to mitigate and adapt to deleterious GEC impacts and focuses on the type of research agenda and strategy development that would allow for more efficient policy formulation, beyond the initiatives currently being enacted.

[1] The current CARICOM members are Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago.

2. CARICOM's economies and agricultural systems

CARICOM is comprised mainly of island nations located in the Caribbean Sea and some countries in South and Central America, lying north of the equator mainly between 5° and 28° latitude and in the western hemisphere between 50° and 90° longitude. The countries are geologically, environmentally, politically, socio-culturally and economically diverse. The geographical scope leads to variations in resource endowments and agro-ecological conditions across the countries. The countries have a wide range of natural resources and ecosystem biodiversity that serve as foci for a tourism sector (dominant in most of the countries) as well as the agricultural sector.

World Bank data (Table 1) convey considerable variation in the area of agricultural land within CARICOM states. Historically this land was used to cultivate export crops. Domestic agriculture was neglected, which created major on-going challenges and structural weaknesses in this sector. These challenges included the use of marginal lands for domestic food production; poor road access to available lands and markets; absence of adequate physical marketing facilities; poor and ineffective institutional support. Seasonal patterns of rainfall and drought make availability of drainage and irrigation infrastructure critical for efficient production, but this has been generally neglected for domestic agriculture.

The non-uniform contribution of the agricultural sector across the member countries reflects varying contributions to food availability in the region. The agriculture value added in the gross domestic product (GDP) in 2003 ranged from 31.4% to 27.9%, respectively, in Guyana and Haiti, to 3.8% and 1.1%, respectively, in Antigua and Barbuda and Trinidad and Tobago (Table 1). Measured in constant 2000 US dollars, the sector's output in 2003 for these countries is 194.57 million for Guyana, 0.78 million for Haiti, 23.42 million for Antigua and Barbuda and 106.93 million for Trinidad and Tobago (World Bank, 2007).

In a comparison of GDP contributions of agriculture, industry and services (Table 1), Guyana is the only country

Table 2 – Selected economic performance indicators for CARICOM countries, 2003.

Countries	Employment indicators		
	Agriculture (%)	Manufacturing (%)	Services (%)
The Bahamas	3.0	15.8	80.9
Barbados	4.6	17.6	66.8
Belize[a]	27.5	17	55.3
Dominica[b]	27.3	18.2	57.8
Grenada[c]	13.8	23.9	58.6
Guyana	27.8	22.6	47.9
Haiti	50.6	10.7	38.7
Jamaica	20.4	17.4	62.1
St Lucia	11.4	17.7	52.7
St Vincent/ Grenadines[d]	15.4	19.7	56.3
Suriname	6.1	14.5	75.4
Trinidad/Tobago[e]	6.9	28.4	64.4

Source: Compiled from World Development Indicators Online, World Bank (2007).
[a] Data for year 1999.
[b] Data for year 1997.
[c] Data for year 1998.
[d] Data for year 2001.
[e] Data for year 2002.

where agriculture is the largest sector. For most of the other countries, however, the services sector contributes in excess of 50% to GDP. Generally, the output from agriculture exceeds 10% of total GDP in only five instances.

Despite its low contribution to GDP, the agricultural sector plays a critical role in food and livelihood provision and the servicing of other economic sectors such as tourism and manufacturing. Agricultural employment accounts for at least 20% of total employment in five countries. It exceeds 50% in Haiti and is close to 30% in Belize, Dominica and Guyana (Table 2). This profile suggests significant risk for many households if agriculture systems are stressed. In contrast, the services sector in all the countries accounts for more than 50% of employment, except for Guyana (48%) and Haiti (39%) (Table 2).

In addition to land-based resources, the Caribbean Sea is an important protein source, major livelihood provider and foreign exchange earner for CARICOM states. Approximately 7% of protein consumed in the Caribbean is from fish. Main fisheries resources include large pelagics, small coastal pelagics, reef fish, lobster, shrimp and molluscs (CARSEA, 2007). Coral reefs, mangroves and sea-grass beds provide a habitat for many commercial fish species and protect coastal areas. Coral reefs also provide sources of sand, protect beaches from erosion and are a vital tourist attraction. There have, however, been significant human and environmental impacts on Caribbean Sea ecosystems, services and livelihoods (CARSEA, 2007).

One noticeable characteristic of CARICOM economies is a potential vulnerability to food insecurity because of the high dependence on food imports and foreign export earnings (see Fig. 1). Apart from Guyana and Belize, CARICOM states are net food importers. The region also lags significantly behind other developing countries and the rest of the world in its per-capita food production (Fig. 2). This makes CARICOM states vulnerable to higher energy and food prices, as well as food trade restrictions.

3. Food security and vulnerability issues as related to availability and affordability

Although more food secure than some parts of the developing world, CARICOM states exhibit pockets of severe food insecurity, expressed by percentage of undernourished (Table 3). From 1990 to 2004, the incidence of undernourishment declined over the period for most countries except Dominica. However, in Haiti, the level of undernourished persons (46%) reflects the impact of its poor socio-economic, political and environmental institutions on food provisioning services. Further, three other CARICOM states exhibit undernourishment of at least 10%: Trinidad and Tobago, St. Kitts and Nevis, and St. Vincent and the Grenadines.

Over the past decade the region's food import dependency has exacerbated, partly because trade liberalization influenced cheaper food imports. In 2006, 85.5% of the region's food supplies were imported (CARICOM Secretariat, 2008). Barba-

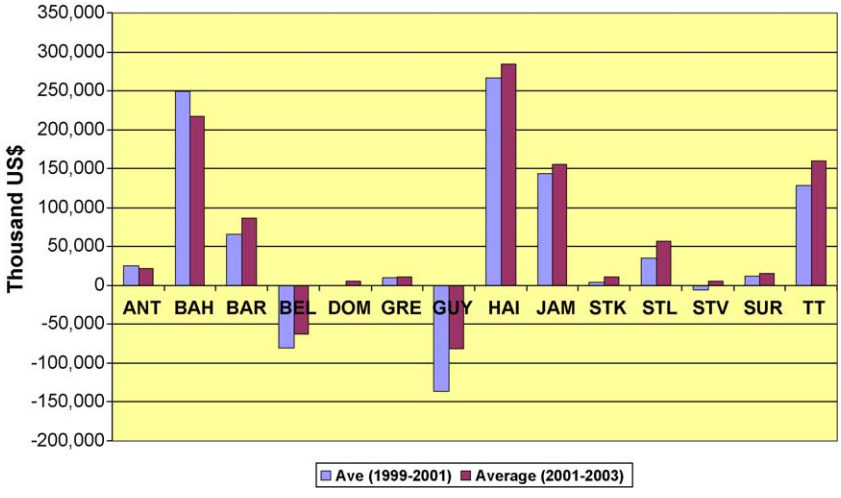

Fig. 1 – Average net food imports of Caribbean countries, 1999–2003. *Source*: FAO (2004, 2005).

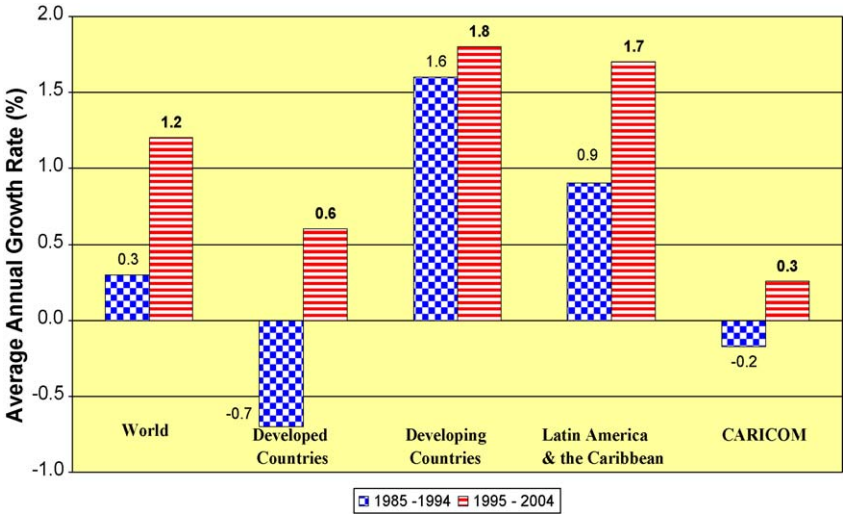

Fig. 2 – Per capita food production, 1985–2004. *Source*: FAO (2004, 2005).

dos' food import bill jumped from just under US$ 172 million in 2002 to about US$ 250 million in 2007, representing a 45% increase in 5 years (Springer, 2008). When food prices rise therefore, the region's capacity to purchase food diminishes.

Additionally, the increased food prices are expected to have a significant effect on the short-run nutritional status of children, diminishing in the long-run (Løvendal et al., 2007). Despite higher poverty levels, rural children are better able to cope because of access to home-grown food (Løvendal et al., 2007) and greater reliance on neighbours and family members to provide food in times of need, unlike the urban poor.

Given the export bias of it agricultural production, the region's food security is particularly vulnerable to the declining terms of trade in agriculture. Since most agricultural exports are primary commodities such as bananas, historical falls in commodity prices and export volumes, lead to significant reductions in agricultural export earnings because of loss of preferences in export markets (Ford et al., 2007).

Table 3 – Percentage of population undernourished in CARICOM member states.

Country	Population undernourished (%)	
	1990–1992	2002–2004
Antigua	NA	NA
Bahamas	9	8
Barbados	<2.5	<2.5
Belize	7	4
Dominica	4	8
Grenada	9	7
Guyana	21	8
Haiti	65	46
Jamaica	14	9
St. Kitts	13	10
St. Lucia	8	5
St. Vincent	22	10
Suriname	13	8
T&T	13	10

Source: UNDP Human Development Report 2007–2008 (UNDP, 2008).

Being small states, CARICOM countries are also expected to experience approximately 25% higher levels of income volatility than large states (FAO, 2007a). CARICOM also recently experienced significant rises in food prices. In Haiti, this resulted in violent protests, paralysing business activity (FEWSNET, 2008). In Trinidad and Tobago food prices make up 18% of the retail price index (RPI), and since 1994, these prices have been rising faster than any other component of the basket and the associated world price of related commodities. While the RPI food basket less than doubled since 1994, the price of food has increased five-fold (Løvendal et al., 2007). This rapid increase and maintenance of high food prices is reported to be the result of a poor domestic marketing and production environment (Løvendal et al., 2007). Further, wage rate increases have not been able to surpass the level of inflation, particularly in recent years, thus the poor are more vulnerable as a large percentage of their income is spent on food.

Ericksen (2008b) highlights exposure, sensitivity, coping and adaptive capacity to shocks as well as threats and stress as key criteria in determining the extent of vulnerability. Application of these criteria deems many sections of CARICOM society vulnerable, or potentially so, especially in light of current and anticipated environmental changes. A study focused on Jamaica and St. Lucia (FAO, 2007b) identified specific vulnerable groups: fisher-folk; rural subsistence farmers; sugar workers and their dependents; urban marginal women; casual and unskilled labourers; unemployed and under-employed, especially in rural areas; elderly with limited financial support; infants and children, particularly in low income homes; youths—especially in inner cities; banana farmers; persons with chronic diseases or disabilities. This vulnerability is illustrated by briefly examining the circumstances of some of these groups.

3.1. *Indigenous people*

CARICOM's indigenous population inhabits both rural and urban areas. The largest groups exist in Belize, Dominica, Jamaica and Suriname, who largely experienced deteriorating developmental status (such as the HDI) over the years

Table 4 – Quality of life indicators for Belize, Dominica, Guyana, And Suriname.

Country ranking	Human development index			Adult illiteracy (%)	Population below national poverty line	Child malnutrition (%) underweight	Under 5 mortality rate per 1000	Average dietary energy supply
	1998	2002	2007	1998	1989–1994	1993–2000	2000	1997–1999
Belize	73	58	80	6.8	35.0	6.2	38	2893
Dominica	41	61	71		33.0	5	17	2972
Guyana	100	103	97	1.9	43.0	12	8.7	2676
Suriname	65	74	85	7.0	47.0		19	2686

Source: Modified from Gomes (2004), Annex 4; Table 1; UNDP (2007).

(Table 4). In these countries, high levels of poverty and income inequality (Gomes, 2004) critically threaten their food security.

In addition to this poor national outlook, the indigenous people generally experience a low quality of life, and they are the poorest of the poor (Gomes, 2004). Focus group discussions with Garifuna and Mayan people in two Belizean villages indicated that their communities were characterized by: malnutrition, lower birth weight, nutrient deficiencies; highest rates of growth retardation among school-age children; the highest child mortality rate (Gomes, 2004). They also experienced poor access to jobs, housing, potable water, health facilities and schools. Many indigenous communities live in coastal or low-lying areas, where unregulated fishing external to the communities threaten their access to food resources. Their increased fishing effort[2] yields smaller catches.

3.2. *Banana farmers*

The banana sector has been very important in the economies of St. Lucia, St. Vincent and the Grenadines, Dominica and Grenada and to a lesser extent Belize, Jamaica and Suriname. The sector created high direct employment and income generation, particularly in rural areas, and large multiplier effects.

The sector experienced a fall in export volumes and earnings from 277,441 tonnes valued at US$ 143.4 million in 1990 to 24,160 tonnes, valued at US$ 12 million in 2005 (Ford et al., 2007). This resulted in significantly less rural employment, evidenced by a fall in registered banana farmers in the Windward Islands[3] from 23,100 in 1994 to 5300 in 2003 (Ford et al., 2007). Imports are now funded by the tourism sector, which is characterized by significant foreign exchange leakages (Ford et al., 2007), and which is also heavily subject to environmental stresses.

Banana farmers now primarily produce for the fair trade niche market (Ford et al., 2007), but are still very vulnerable to significant loss of income from changes in rainfall patterns, as most systems are rain-fed. They are also vulnerable to tropical storms and hurricanes since 9 months are needed to recoup production following a storm and they are without income during that period. Ex-banana farmers have experienced little retraining in viable economic diversification alternatives and reduced cash flow has further exacerbated their ability to adapt to environmental changes.

3.3. *Urban poor*

Inner city dwellers, an often ignored vulnerable group, are rapidly increasing across the Caribbean. In 2006, 51.5% of inner city persons in Jamaica were 35–54 years of age, largely skilled artisans, unskilled or employed as labourers (22%) (FAO, 2007b). Approximately 25% spent most of the household income on food, while almost 52% spent about half of all household income similarly. Inner city coping mechanisms included use of their savings (61.3%), borrowing from friends or relatives (60.3%) or relying on remittances from relatives abroad (29.8%). This scenario mirrored the circumstances of inner city persons in St. Lucia and may be considered fairly representative of inner city residents throughout CARICOM. Since a large portion of their generally fixed income is spent on food, urban dwellers are unlikely to sustainably adapt to rapidly rising food prices, resulting in compromises to their food purchasing power (FAO, 2007b).

4. Environmental stresses on Caribbean food systems

The livelihoods of the majority of the population of CARICOM countries are dependent on the natural environment, whether through agriculture, fishing or tourism. Any environmental stresses and changes can have a deleterious impact on agricultural production, food availability and income generation.

Caribbean natural and social scientists, in their varying roles in research, development and policy making, have identified extreme weather and climate events[4], water quality, land degradation and fisheries issues[5] as critical environmental issues in determining current and future food security (GECAFS, 2006, 2007). We will now discuss how these environmental events have or can impact on Caribbean food systems, especially production.

4.1. *Current environmental stress*

4.1.1. *Extreme weather and climate events*

Rainfall in the Caribbean islands is characterized by a wet season from May/June to November/December when on average 70–80% of the rainfall occurs and a dry season during the rest of the year (Enfield and Alfaro, 1999). In northern

[2] More frequent trips for longer hours.

[3] Dominica, Grenada, St. Lucia and St. Vincent and the Grenadines.

[4] In particular tropical cyclones, drought and floods.

[5] Such as stock levels, sea surface temperatures, sea levels and salinity.

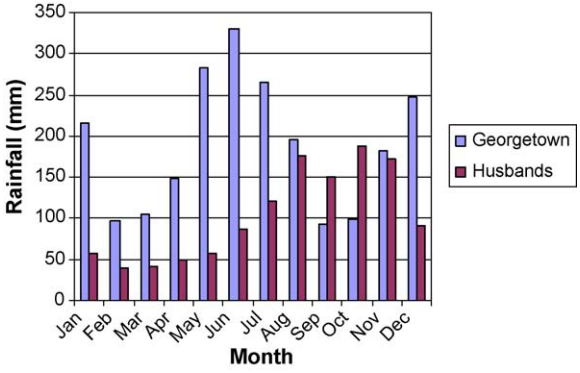

Fig. 3 – Rainfall patterns in Georgetown, Guyana and Husbands, St. James, Barbados.

Guyana, however, there are two wet seasons and two dry seasons (see Fig. 3). Within this general trend, variations can occur such that very wet spells are experienced during the dry season and vice versa, often as a result of the El Niño Southern Oscillation, sea surface temperature variations (Enfield and Alfaro, 1999; Taylor et al., 2002; Giannini et al., 2001; Laing, 2004; Stephenson et al., 2008) and the North Atlantic Oscillation (Charlery et al., 2006). Winds are predominantly easterly and strongest during the dry season. These strong winds, along with low humidities, enhance evapotranspiration during the dry season hastening water stress in crops. The region is prone to tropical cyclones between June and November, with at least seven of these being of tropical storm strength[6] each year in the Caribbean and Gulf of Mexico (Saunders and Lea, 2007). These climatic conditions and variations influence agricultural output and export potential, because agricultural production is primarily rain fed and is vulnerable to extreme weather events. Extreme events are themselves catalysts of environmental change (for example from landslides due to heavy rains).

Drought associated with the well documented 1997–1998 El Niño negatively impacted Amerindians (Sarmiento, 1998), left 35% of rice fields uncultivated in Guyana (FAO, 1998), devastated the sugar industry in Jamaica (Encyclopedia of the Nations, 2008) and caused major crop losses (Table 5). Floods resulted in major economic losses in Guyana in 2 consecutive years (ECLAC, 2005a, 2006). Floods in Suriname in 2006 (Buitelaar et al., 2007) were particularly harsh on rural farmers whose entire food supply and livelihoods are centred on their farm production. None of these floods was associated with tropical cyclones. However, in the Caribbean islands, tropical cyclones catalyse many instances of flooding and landslides, which in turn trigger major agricultural losses and the disruption of many livelihoods, as experienced in Jamaica (ECLAC, 2001) and Haiti (UNEP/OCHA, 2004; ECLAC, 2005b). Tropical cyclones also cause major wind damage as witnessed in the aftermath of Hurricane Ivan in Grenada and Jamaica (OECS, 2004; ECLAC, 2004a). Ivan affected the livelihoods of approximately 30,720 of those directly and indirectly employed in the spice industry in Grenada (OECS, 2004); this out of a total population of around 90,000.

Another concern to CARICOM is that a single tropical cyclone can create damage in multiple countries. This occurred in 2004 when Ivan affected Jamaica, Haiti and Grenada and again in 2007 when Hurricane Deane struck St. Lucia, Dominica, Jamaica and Belize. There must also be concern when multiple tropical cyclones impact one country in the same season as happened in Haiti in 2008, when four such storms struck in 30 days (Spencer, 2008; Lindsay, 2008).

4.1.2. *Other environmental stresses*

Human land use, including some traditional soil management practices by farmers, may foster further weather-induced land degradation; increasing nutrient and soil loss in watersheds (McDowell, 2001) and forests (McDonald et al., 2003). Ahmad (2001) alluded to large areas of abandoned, degraded land across the Caribbean, many of which may be beyond rehabilitation due to thin soil cover. Loss of forested lands in highland areas and watersheds (as in the Northern Range of Trinidad) to farmlands, housing and squatting, quarrying and other developmental activity has led to soil erosion and a reduced water recharge capability (Northern Range Assessment, 2005). Haiti loses as much as 36 million tonnes of soil every year resulting in, *inter alia*, declining crop yields and damage to coastal marine resources (UNEP/OCHA, 2004).

Coral reefs and the biodiversity they support are under severe threat in Caribbean waters (CARSEA, 2007). Fisheries, coastal protection and tourism are some of the vital services provided by this ecosystem. Apart from its role in food security, fisheries are also a major livelihood provider in many coastal regions for fishers, fish salesmen, boat-makers, net builders and other entrepreneurs. It is estimated that about 130,000 persons depend on fisheries for their livelihood (CARICOM Fisheries Unit, 2002). In some CARICOM states GDP from fisheries (excluding processing) is as high as 8% (CARICOM Fisheries Unit, 2002).

Decline in hard coral cover in the Caribbean basin was estimated at 80% since the 1970s (Gardner et al., 2003). This decline has been attributed to elevated sea temperatures (McGrath and Smith, 2003; Oxenford et al., 2007); hurricane damage (Woodley et al., 1981); disease, sometimes through transport of pathogens in Sahara dust and shipping (USGS, 2000); pollution, particularly from sewage, sedimentation and agricultural fertilisers (Burke and Maidens, 2004); overfishing, particularly of algal-growing fish; direct damage from human activity, including from boat anchors and dynamiting (CARSEA, 2007). Fish stocks in the region are also prone to being affected by climatic events occurring outside the region. Fish kills in the Eastern Caribbean have been linked to bacteria transported by fresh water plumes emanating from the Orinoco River in Venezuela, following heavy Amazonian rains (Willoughby et al., 2002). Table 5 illustrates, by some examples, the impacts of environmental shocks on agricultural systems in CARICOM.

4.2. *Future environmental stresses*

Water availability and quality are increasing threats to future food security in Caribbean island states (Mimura et al., 2007).

[6] Tropical cyclones include tropical depressions (wind speeds of 23–38 miles per hour), tropical storms (wind speeds of 39–73 miles per hour) and hurricanes (with wind speeds of at least 74 miles per hour).

Table 5 – Examples of extreme environmental events impacting food security in CARICOM states.

Environmental stressor	Country/ subregion	Year/period	Impact (dollar amounts: millions, US$)
Drought	Guyana	1997–1998	15,000 Amerindians affected (Sarmiento, 1998), 35% of rice fields uncultivated (FAO, 1998).
	Jamaica	1997–1998	Major losses in sugar sector. Government offered $100 in assistance (Encyclopedia of the Nations, 2008).
	Jamaica	1999–2000	Crop losses of approximately $6 (Jamaica Information Service, 2007).
Flood	Guyana	2005	59.5% GDP in total losses. Agriculture losses $55 (ECLAC, 2005a).
	Guyana	2006	4.6% of GDP. Agriculture losses $22.5 (ECLAC, 2006).
	Haiti	2008	Flooding associated with the passage of four tropical cyclones in less than 1 month. Over 600 dead with major losses in agriculture and further spiraling of food prices (Spencer, 2008; Lindsay, 2008).
	Suriname	2006	2.3% of GDP in total losses. Agriculture losses $15.6 the majority from traditional agriculture in the rural interior (Buitelaar et al., 2007).
Tropical cyclones	Bahamas	2004	Hurricanes Frances and Jeanne, 7.3% of total GDP. Agriculture losses $45 (ECLAC, 2004b).
	Belize	2007	Hurricane Deane total damage $92.1. Agriculture losses $59.9 (ECLAC, 2007a).
	Dominica	2007	Hurricane Deane. Agriculture losses $17 (ECLAC, 2007b).
	Grenada	2004	Hurricane Ivan 200% GDP in total losses. Agriculture losses $40.91% of forests and watersheds stripped of vegetation (OECS, 2004).
	Jamaica	2001	Hurricane Michelle 0.8% losses in GDP. Agriculture losses $11.5, mainly due to flooding (ECLAC, 2001).
	Jamaica	2004	Hurricane Ivan 8% GDP in total losses. Agriculture losses $138 (ECLAC, 2004a).
	St. Lucia	2007	Hurricane Deane, 2.5% of total GDP. Agriculture losses $8.7 with banana accounting for 80.3% (ECLAC, 2007c).
Coral bleaching	Bahamas	1998	Death of *Acropora cervicornis* reefs and severe damage to *A. palmate* associated with elevated sea temperatures (McGrath and Smith, 2003).
	Barbados	2005	70.6% of all coral bleached. Associated with elevated sea temperatures. Experienced across the region (Oxenford et al., 2007).
Fish mortality	SE Caribbean	1999	Loss of reef fish due to bacteria emanating from the Orinoco river after heavy rain in the Amazon (Willoughby et al., 2002).
Landslides	Haiti	Many years	Experienced on denuded steep slopes with poor land management during high rainfall (McBride and Voss, 1990; UNEP/OCHA, 2004).

Despite uncertainty surrounding future rainfall levels, the majority of 21 models project a decrease of about 5–15% across the Caribbean, particularly in the Antilles in June through, July and August (Neelin et al., 2006; Christensen et al., 2007). This will likely reduce agricultural yields in many CARICOM islands because of low soil and irrigation water availability. Further stress to water supply is also likely from salt water intrusion caused by sea level rise and over-pumping (Farrell et al., 2005; Karanjac, 2005; Sutherland et al., 2005). In Jamaica, salt water has been discovered in wells located 10 km from the coast (Karanjac, 2005), while in Guyana, concerns exist over saline intrusion of water into the rivers and coastal soils (Narayan, 2006).

There is also the likelihood of increased flooding from higher rainfall intensity, irrespective of the overall projected decrease in precipitation. Such trends are already evident in the region since the 1950s (Peterson et al., 2002). Sea level rise can cause greater inundation of coastlines, more severe storm surges and beach erosion with serious implications for the region's tourism sector. Guyana, with its low-lying coastline, is particularly threatened by sea level rise as most of its population, industrial activity, businesses and agricultural production lie within 16 km of the coastline. Greater sea level rise would increase salinity further upstream and salinise a greater area of soils (Narayan, 2006).

The effect of anthropogenic climate change on tropical cyclone activity, particularly in the north Atlantic, is without consensus. There are arguments for increased frequency (Oouchi et al., 2006), greater intensity and destructive potential in the North Atlantic (Webster, 2005; Emanuel, 2005), as well as much skepticism about future storm impact (Pielke et al., 2006; Landsea, 2005). However, the future is resolved, it is evident that the experience of just one hurricane can impact heavily on food availability and livelihoods across CARICOM! This is so whether or not the impacts are on crops, food storage and other farming infrastructure, or on marine habitats that support fisheries.

Increased sea temperatures will continue to add to the stress on coral reefs and the biodiversity they support. Owing to reef degradation, reef fisheries production is predicted to decline from 100,000 metric tonnes annually to 60,000–70,000 metric tonnes annually by 2015, a potential net loss of US$ 95 million to US$ 140 million (Burke and Maidens, 2004). This excludes the potential losses from impacts on tourism and coastal protection. Variability in fish stocks in the future may well be influenced by the sea temperatures, such that species traditional to the waters of the Caribbean may migrate to more comfortable regions, or the habitat support a smaller fish population.

As tropical zones expand poleward (Fischer et al., 2005), climate change may have some indirect consequences as it is likely that current export commodities might be grown in traditional temperate markets. In fact, with unabated import

dependence, many locally grown foods might well be imported from more traditional temperate markets, particularly if it is cheaper!

5. Exploring policy options and adaptation strategies in light of GEC

5.1. *Current policy responses and initiatives*

Beginning in 1975 with the Regional Food Plan, various regional policy initiatives were implemented to mitigate the vulnerability of CARICOM to food insecurity. Those being actively pursued are the Regional Negotiating Machinery (RNM), the CARICOM/FAO Regional Special Programme for Food Security (SPFS), the Jagdeo Initiative (JI) and the Caribbean Cooperation in Health (CCH) Initiatives. The general programme goal is to improve primary and value added agricultural output; promote agricultural diversification and expand market share of traditional commodities. Complementary goals are market penetration for new products; increased employment and improved quality of life of the citizenry. However, systems to measure the overall effectiveness or impact of any of these policy measures on mitigating food insecurity are absent. Another critical deficiency is the lack of a targeted focus of the respective programme elements that integrally involve vulnerable groups.

The JI, endorsed by CARICOM Heads of Government in 2005, is the current regional policy prescription for increasing agricultural output and improving international competitiveness. It describes important medium term goals for the sector and its contribution to economic and social development, environmental sustainability and food security.

The Regional Transformation Programme for Agriculture, a complementary policy initiative to the JI, also refers to areas of action critical for addressing GEC. The initial phase of the Regional Programme for Food Security has contributed to the rehabilitation and modernization of small-scale irrigation and the training of experts in the areas of agricultural policies and markets. Some Caribbean countries received assistance to formulate national medium-term investment programmes for their agricultural sectors. These have been used for the preparation of bankable investment project profiles aimed at enhancing the economic and institutional environment. Projects' scope encompassed technologies for crop production and processing, creation of enterprises, and trade facilitation. The positive results during this phase lead to the expansion of the initial programme, and informed the design of a follow-up programme for the development of the rural sector.

However, despite the establishment of national disaster response agencies and fully or partially developed disaster policies, a number of key deficiencies were identified. These included limited private sector inclusion in disaster planning; absence of agriculture-specific plans; lack of resources for comprehensive disaster management; weak institutional and infrastructural support. In addition the plans revealed inadequate consideration of household-level adaptation strategies.

There are two regional initiatives pertaining to natural disasters and climate change, that impact agriculture. The Caribbean Disaster Emergency Response Agency implements a programme that emphasizes disaster loss reduction through risk management (CDERA, 2007). One goal is to incorporate the mainstreaming of disaster risk management into agriculture, focusing on result-based management. The Caribbean Community Climate Change Centre was established in 2002 to provide an institutional mechanism for the coordination of climate change activities. The centre is mandated to build regional capacity to sustainably combat challenges posed by climate occurrences. It executes several projects aimed at mainstreaming climate change in development planning and building national capacity for climate change adaptation in agriculture, water resources, tourism and coastal areas (CCCCC, 2008).

These policy initiatives combine to increase a macro-level sensitivity to the impact of GEC and its potential effect on agricultural production and food affordability. However, we submit that they fail to sufficiently stimulate focus on mitigating the effects of environmental stresses at the micro-level on the core elements of CARICOM food systems that are especially vulnerable.

5.2. *Responding to GEC threats to CARICOM food systems*

Regional and global experiences (DPA, 2001; Aggarwal et al., 2004; Verchot et al., 2007) highlight the extreme vulnerability of agriculture to GEC. From earlier discussions this extrapolates to other expressions of vulnerability, particularly in an export-agriculture environment. There is a dearth of empirical studies on mitigating the impact of GEC on the Caribbean. Consequently, we shall examine climate related risk reduction and adaptation strategies pursued globally, to illustrate lessons that may be relevant for the Caribbean.

One critical issue is the timely prediction of extreme weather events and the appropriate dissemination of that information. Nicholls (2001) argues that the application of improved scientific prediction techniques is critical to reducing vulnerability to climate change. This is particularly important for the Caribbean since forecasting for islands is often more difficult than for large landmasses. Ongoing research on forecasting weather events and seasonal climate changes such as drought and excessive rainfall (CIMH, 2008; McGill University, 2008) will improve planning in the medium term for crucial agricultural production decisions.

Prabhakar and Shaw (2007) stress the value of spatial and temporal climate information for input into community level mitigation plans. Communication strategies must cater to inherent cognitive and interpretative biases that exist within the public, the media and decision makers (Nicholls, 2001). Given the disparity in size across the Caribbean countries, these issues require differential attention in the respective countries.

Döll (2002) cautioned on the need to undertake comprehensive assessments of domestic and industrial water demand, since information gaps created uncertainty of irrigation requirements. This would be imperative in the Caribbean with the likelihood of reduced precipitation associated with climate change (Neelin et al., 2006; Christensen et al., 2007).

An assessment of climate change impacts on one or more of eight sectors[7] in 55 countries[8] was sponsored by the United States Country Studies Program (Smith and Lazo, 2001). The study evaluated respective countries' sensitivity (how affected), adaptation (coping arrangements) and vulnerability (net effect) to climate change. Local researchers faced constraints of technical capacity, financial capacity and data availability. However, with appropriate model selection some preliminary conclusions were possible for sensitivity and vulnerability in some of the target sectors (Smith and Lazo, 2001). For resource-poor CARICOM countries, the lesson from this is that the adoption of a similar strategy of integrated studies of GEC impacts could yield useful insights on sensitivity, adaptation and vulnerability while simultaneously building local technical capacity for evaluating and combating GEC challenges.

Pielke and Sarewitz (2005) re-emphasise that temporal changes in human population characteristics are key factors influencing the impact of climate phenomena on humans and the environment. They argue that adaptation strategies should focus predominantly on societal governance and conclude that policy interventions focused on the adaptation of societal reactions to climate impacts will be a more effective risk reduction strategy than those attempting to modify behaviour that contributes to climate change. Etkin and Stefanovic (2005) support this view with their argument of interdependency between society and its natural environment. They posit that an interdisciplinary approach to maintaining this balance through disaster mitigation will serve to reduce society's vulnerability to catastrophic environmental occurrences. From their study of India's vulnerability to drought, Prabhakar and Shaw (2007) concluded that an optimal risk reduction strategy should be a bottom up one, integrally involving the local communities. Such a strategy enhances the local personnel's understanding of the communities' vulnerabilities and the relationship with the communities' developmental level. A common thread linking these three investigations is that involvement of the vulnerable groups is a prerequisite to the adoption and implementation of sustainable strategies to combat environmental stresses on food security. The logical extension of this argument is that a bottom up strategy empowers those most vulnerable to the impacts of extreme weather events and reduce their dependence on external support.

CARICOM countries can distil lessons from these experiences for mitigating the impact of and adapting to GEC. Foremost among these is the involvement of potentially vulnerable groups and communities in developing adaptation and mitigation strategies that embrace societal governance as the fundamental underlying principle of adaptation and mitigation. Other elements include, *inter alia*:

- An interdisciplinary research agenda designed to address current and potential environmental shocks and changes.
- The utilisation of appropriate level of scientific knowledge and techniques to build local technical capacity and enhance societal governance.
- The employment of communication processes that effectively convey information to the population segments at risk, the media, decision makers and any other key audiences.
- The establishment or refinement of institutional arrangements to be supportive of the evolving mitigation and adaptation strategies.

In the Caribbean context, the inclusion of research on cross-scale interactions is important, since institutions and governance in the region operate primarily on national scales, but also collectively facilitate regional policy instruments through CARICOM. Researchable questions exist at both the national and regional scale, requiring links between issues at the two levels. An example of this might be how the Caribbean single market and economy impacts food security at the national level. For example, would there be benefit to enhancing intra-regional trade to promote competitive prices of domestically produced foods while maintaining the livelihoods of the farmers within the region? Or, would a regionally coordinated food relief plan, encompassing storage facilities in multiple locations across the region, effectively complement national plans at times of disaster?

Effective communication is a necessary element of any GEC impact mitigation plan, is pivotal to obtaining effective policy impact and must be sufficiently dynamic to convey information on the core issues to the respective audiences for optimal buy-in. The successful implementation of GEC policy measures will also require appropriate institutional support at both national and regional levels. At the national level, for example, designing objective criteria to evaluate impact of various policy measures and monitoring implementation are key requirements. One regional level institutional support element is the strengthening of existing capacity to provide timely spatial and temporal information about GEC events to relevant stake holders. Appropriate institutional arrangements will necessitate building on extant national level systems and effectively networking with those that exist globally, such as with the United States of America's National Oceanic and Atmospheric Administration, which collaborates with Caribbean agencies in providing meteorological information.

Limited inclusion of the private sector in disaster planning reported earlier does not fit with the philosophy of societal governance nor does it auger well for a sustainable strategy. Private sector involvement should be actively encouraged by emphasising the benefits to the private sector, of successful disaster mitigating measures. One avenue for the involvement of the private sector is through the provision of insurance to mitigate the risk from disasters. The experience of crop insurance in the Caribbean is extremely limited and confined to the Dominican Republic, Jamaica and the Windward Islands (Edmund, 2006). Consequently, this mitigating option is one that likely holds long-term prospects.

The Caribbean science plan and implementation strategy (CSPIS) (GECAFS, 2007) is timely in its attempt to elaborate an approach to promoting a scientific approach to policy formulation, mitigation and adaptation to GEC in the

[7] These were coastal resources, agriculture, grasslands/livestock, water resources, forests, fisheries, wildlife, and health.

[8] The studies encompassed eight Latin American countries and Central America (including Belize) as a region.

Caribbean. We suggest that it will be useful to consider amending the elaborated CSPIS approach to include local researchers, country specific studies and the policy issues discussed above, as appropriate to the circumstances.

6. Conclusion

The global trade, energy and economic situations have placed the food security of many countries in precarious positions. GEC is expected to further stress food security, through impacts on food availability, its affordability and the livelihoods of vulnerable groups. Even though current agriculture and food security policy initiatives in CARICOM do not specifically address GEC, the topical issues of climate change and sustainable development provide an avenue for these concerns to be considered. Recent GEC impacts in the region and globally illustrate the fragility of food production systems. The high price of food items due to escalating energy prices and extreme weather events in food producing areas across the globe, expose the vulnerability of CARICOM states because of their high levels of food imports and declining trade and economic positions.

In the absence of GEC-influenced research in the Caribbean, lessons can be drawn from relevant global circumstances on the formulation of Caribbean policy responses to GEC impacts on food availability and food security in the region. Among other things, these lessons point to the value of the involvement of the vulnerable population segments in the planning and implementation process, the importance of the conduct of interdisciplinary scientific research and the necessity for a supportive institutional environment.

The CSPIS provides a platform for initiating research into Caribbean food systems vulnerability and the development or adaptation of policy options (GECAFS, 2007). This is particularly timely in a region where food security and agricultural production are often, mistakenly, used synonymously (GECAFS, 2005).

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